Alternatives to Methyl Bromide for California Cropping Systems

ARS LOCATION:
Water Management Research Unit
9611 S. Riverbend Ave.
Parlier, CA 93648

PRINCIPAL INVESTIGATORS:
Dong Wang, Supervisory Soil Scientist
Phone: 559-596-2852; E-mail: dong.wang@ars.usda.gov

Suduan Gao, Soil Scientist
Phone: 559-596-2870; E-mail: suduan.gao@ars.usda.gov

Jim Gerik, Plant Pathologist
Phone: 559-596-2865; E-mail: james.gerik@ars.usda.gov

PROJECT OBJECTIVES:

1. Test emerging methyl bromide (MeBr) alternative chemicals for their efficacy in controlling various soilborne plant pathogens.
2. Test MeBr alternative chemicals, rates, and application methods to meet California certification standards for nematode-free production of tree, vine, and rose nurseries.
3. Develop various application methods, soil amendments, and physical barriers to reduce emissions and enhance efficacy of chemical alternatives to MeBr
4. Develop integrated weed control strategies using combinations of MeBr alternative fumigants, herbicides, biofumigants, and non-chemical weed management techniques.

MAJOR ACCOMPLISHMENTS (2007–2010):

Long term effects of methyl bromide alternatives on nematode control in grape replant:
In an eight year grape replant trial, ARS scientists in Parlier, CA found that 1,3-dichloropropene plus chloropicrin, iodomethane plus chloropicrin, and propargyl bromide generally controlled root-knot and citrus nematodes similar to methyl bromide. However, only propargyl bromide treatments had grape yield equivalent to methyl bromide during the first four years after treatment. Rootstock selection had a profound effect on nematode populations; the root-knot resistant rootstock 'Freedom' kept nematode numbers low regardless of preplant fumigation treatment. Where this particular race of root-knot nematode is the major replant problem, use of a resistant rootstock may reduce the need for preplant fumigation; however other replant problems such as different nematodes or soil-borne pathogens may still exist.

Crop response of new methyl bromide alternatives in grape replant:
In the past three years, ARS scientists in Parlier, CA conducted three field trials; two plot scale experiments at the USDA-ARS Parlier facility and one at a grower field demonstration trial near Fresno, CA. In all these trials, previous grapevines were removed, and fumigation treatments were applied then replanted with new vines (a wine grape and a raisin grape). The first plot experiment was initiated in summer 2007 and repeated in 2008 and 2009 in a field previously planted with grapes that exhibited root damage from soilborne pathogens. Eight treatments were devised and implemented in a randomized block design with three replications. Caliper vine diameter readings showed that only the non fumigated plots appeared to have smaller

vine diameter readings, a result likely caused by replant diseases. A field demonstration trial was initiated in fall 2008 in a grape grower field near Fresno, CA. The experimental design was a randomized block with three replications for four treatments. The caliper vine diameter readings also showed slower growth in the untreated control. Initial harvest measurements showed similar yield values between the methyl bromide control and all alternative fumigant treatments. The untreated control however showed lower yields than all the fumigated plots. The research demonstrated the necessity of controlling soilborne or replant disease problem in grape replant.

Management techniques for reducing fumigant emissions in grapes:
Through a series of field trials, ARS scientists in Parlier, CA found that surface sealing/treatments such as water seals and stardard plastic tarping over moist soils can reduce emissions to some extent and low permeable films e.g. virtually impermeable film or VIF and totally impermeable film or TIF, reduced the total emission loss most effectively to below 2 percent over a 6 day covering period compared to 30 percent from the conventional polyethylene (PE) film. The ability to significantly reduce emission fluxes will help improve buffer zone restrictions and enable many fields to be fumigated under the newly amended United States EPA regulations. The relationship between soil type, water content, and fumigant emissions was also examined by ARS scientists in Parlier, CA. Results showed that increasing water content up to field capacity reduced emissions of *cis*-1,3-D, *trans*-1,3-D, and chloropicrin while not reducing fumigant concentrations in soil columns. Increasing soil water content significantly reduced peak flux and delayed its occurrence time. This effect appears more significant in fine textured than in coarse textured soils. This finding is useful for growers and fumigation practitioners to develop effective agricultural practices towards reducing fumigant emissions.

Herbicide crop safety in perennial tree and vine nurseries:
Weed control is an important concern for production of woody nursery crops in California. Based on repeated multi-year field trials, ARS scientists in Parlier, CA determined that the most promising herbicides were pendimethalin, thiazopyr, and dithiopyr. The first two of these are already registered and this research effort has encouraged some nurseries to adopt their use. Based on this work, the manufacturer of dithiopyr has requested data and support for possible registration of the product in woody nursery crops. The herbicide oxyfluorfen has shown differential crop safety responses in the nursery. These herbicide studies contributed to the selection and adoption of new weed control strategies in perennial nurseries.

TECHNOLOGY TRANSFER/OUTREACH:

- Presentation on “Vineyard soil fumigation – alternatives to methyl bromide” at the 2009 San Joaquin Valley Grape Symposium, Easton, CA, January 2009.
- Presentation on “Soil fumigation for vineyard replanting” at the University of California Grape Day, University of California Kearney Agricultural Center, Parlier, CA, August 2009.
- Presentations on reducing soil fumigant emissions at the American Chemical Society Annual Meetings: Symposium on Air Quality, Washington, DC, August 2009.

- Presentations at Annual International Research Conference on Methyl Bromide Alternatives and Emission Reductions, 2007-2010.
- Presentations at the ARS-SJVASC and University of California Kearney Ag. Center seminar series and a guest lecture at the California State University Fresno on herbicide resistant weeds in the San Joaquin Valley of California, 2008-2010.
- Annual stakeholder conferences by the Water Management Research Unit, Parlier, CA, 2008-2010.

EXTERNAL SUPPORT:

- ARS, Pacific West Area-wide Project on Methyl Bromide Alternatives, "Vineyard replant – assessment of control efficacy, fumigant movement, and crop response" (Wang, Gao, Hanson, Gerik, and Browne). $270,099. 2007-2010.
- ARS, Pacific West Area-wide Project on Methyl Bromide Alternatives, "Efficacy and 1,3-D emissions with approved nursery stock certification treatment applied with two shank designs" (Hanson, Gao, Gerik, and Wang). $289,269. 2007-2010.
- ARS, Pacific West Area-wide Project on Methyl Bromide Alternatives, "Dynamic flux chambers for fumigant emission measurements" (Gao, Wang, Hanson, Browne, and Ajwa). $85,478. 2008-2009.
- ARS, Pacific West Area-wide Project on Methyl Bromide Alternatives, "Low permeability tarp technology" (Gao, Wang, Hanson, Browne, Gerik, and Ajwa). $45,000. 2010.
- California Department of Food and Agriculture, "Methods to minimize emissions and improve fumigation efficacy in nursery fields" (Gao, Hanson, and Wang). $36,495. 2009-2011.
- NIFA, "Multi-state evaluation of carbonated fumigants and low permeable tarps to reduce application rate, increase efficacy, and minimize emissions" (UFL sub-award to Gao, Gerik, Hanson, and Wang). $132,000. 2010-2013.

COLLABORATORS:

Husein Ajwa, Brad Hanson, and Karen Klonsky, University of California Davis, Davis, CA; Greg Browne, ARS, Davis, CA; Brian Correiar, formerly Jackson and Perkins, Wasco, CA; David Cox, L.E. Cooke Nursery, Visalia, CA; Anil Shrestha, California State University, Fresno, CA; Scott Yates, ARS, Riverside, CA; Jay Gan, University of California Riverside, Riverside, CA; Randy Segawa, California Department of Pesticide Regulation, Sacramento, CA; Robert Woolley, Dave Wilson Nursery, Hickman, CA; Stephen Vasquez, University of California Cooperative Extension, Fresno, CA; Carl Rosen, University of Minnesota, St. Paul, MN; Tom Trout, ARS, Ft. Collins, CO; and John Thomas, University of Florida, Gainesville, FL.

RECENT PUBLICATIONS:

- Mc Donald, J.A., S. Gao, R. Qin, T.J. Trout, and B.D. Hanson. 2008. Thiosulfate and manure amendment with water application and tarp on 1,3-dichloropropene emission reductions. Environ. Sci. Technol. 42:398-402.
- Gao, S., T.J. Trout, and S. Schneider. 2008. Evaluation of fumigation and surface seal methods on fumigant emissions in an orchard replant field. J. Environ. Qual. 37:369-377.

- Qin, R., S. Gao, J.A. McDonald, H. Ajwa, S. Shem-Tov, and D.A. Sullivan. 2008. Effect of plastic tarps over raised-beds and potassium thiosulfate in furrows on chloropicrin emissions from drip fumigated fields. Chemosphere 72:558–563.
- Schneider, S.M., H. A. Ajwa, T. J. Trout, and S. Gao. 2008. Nematode control from shank- and drip-applied fumigant alternatives to methyl bromide. HortSci. 43:1826-1832.
- Gao, S., R. Qin, J.A. McDonald, B.D. Hanson, and T.J. Trout. 2008. Field tests of surface seals and soil treatments to reduce fumigant emissions from shank injection of Telone C35. Sci. Total Environ. 405:206-214.
- Gerik, J.S. and D. Wang. 2008. Dose response of soilborne pathogens to acrolein. Phytopathology 98: S59.
- Hanson, B.D. and S.A. Schneider. 2008. Evaluation of weed control and crop safety with herbicides in open field tree nurseries. Weed Technol. 22:493-498.
- Shrestha, A., B.D. Hanson, and K.J. Hembree. 2008. Glyphsate-resistant hairy fleabane (*Conyza bonariensis*) documented in the central valley. California Agriculture 62:116-119
- Gao, S., R. Qin, B. Hanson, N. Tharayil, T. Trout, D. Wang and J. Gerik. 2009. Effects of Manure and Water Applications on 1,3-Dichloropropene and Chloropicrin Emissions in a Field Trial. J. Agric. Food Chem. 57:5428–5434.
- McDonald, J.A. S. Gao, R. Qin, B.D. Hanson, T.J. Trout, and D. Wang. 2009. Effect of water seal on reducing 1,3-dichloropropene emissions from different soil textures. J. Environ. Qual. 38: 712-718.
- Qin, R., S. Gao, D. Wang, B.D. Hanson, T.J. Trout, and H. Ajwa. 2009. Relative effect of soil moisture on emissions and distribution of 1,3-dichloropropene and chloropicrin in soil columns. Atmos. Environ. 43:2449–2455.
- Guo, M., and S. Gao. 2009. Degradation of methyl iodide in soil: effects of environmental factors. J. Environ. Qual. 38:513-519.
- Qin., R., S. Gao, H. Ajwa, B. D. Hanson, T.J. Trout, and D. Wang, M. Guo. 2009. Interactive effect of organic amendment and environmental factors on degradation of 1,3-dichloropropene and chloropicrin in soil. J. Agric. Food Chem. 57:9063-9070.
- Hanson, B.D., A. Shrestha, and D.L. Shaner. 2009. Distribution of glyphosate-resistant horseweed (conyza canafensis) and relationship to cropping systems in the central valley of California. Weed Sci. 57:48-53.
- Schneider, S.M., B.D. Hanson, J.S. Gerik, A. Shrestha, T.J. Trout, and S. Gao. 2009. Comparison of shank-and-drip-applied methyl bromide alternatives in perennial crop field nurseries. HortTechnology 19:331-339.
- Schneider, S.M. and B.D. Hanson. 2009. Effects of fumigant alternatives to methyl bromide on pest control in open field nursery production of perennial fruit and nut plants. HortTechnology 19:526-532.
- Wang, D., C. Rosen, L. Kinkel, A. Cao, N. Tharayil, and J. Gerik. 2009. Production of methyl sulfide and dimethyl disulfide from soil-incorporated plant materials and implications for controlling soil-borne pathogens. Plant Soil 324:185-197.
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- Wang, Q.X., D. Wang, J. Tang, D.D. Yan, H. Zhang, F.Y. Wang, M.X. Guo, and A. Cao. 2010. Distribution and emission of chloropicrin applied as gelatin capsules. J. Environ. Qual. 39:917-922.
- Wang, D., S. Gao, R. Qin, and G. Browne. 2010. Lateral movement of soil fumigants 1,3-dichloropropene and chloropicrin from treated agricultural fields. J. Environ. Qual. 39:1800-1806.
- Gao, S., B. Hanson, D. Wang, G. Brown, R. Qin, H.A. Ajwa, and S.R. Yates. (accepted Nov 2009) Methods for minimizing emissions from pre-plant soil fumigation. California Agriculture
- Gao, S., B. Hanson, R. Qin, D. Wang, and S.R. Yates. (accepted Aug 2010) Developing agricultural practices to reduce emissions from soil fumigation using field plot tests. J. Environ. Qual. (accepted Aug 2010)
- Wang, D., S.R. Yates, and S. Gao. (accepted Sept 2010) Chloropicrin emissions after shank injection: two-dimensional analytical and numerical model simulations of different source methods and field measurements. J. Environ. Qual.